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Gestural, signed and spoken modalities in early language development: The role of linguistic input*

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The aim of the present study was to examine potential effects of early exposure to sign language on the use of communicative gestures by a bilingual hearing child of deaf parents. Data collected monthly during the first two years were analyzed in order to identify types and tokens of communicative gestures, words, and signs and the ways in which they were combined. These data are compared with those obtained from 12 monolingual hearing children observed at 16 and 20 months of age who were exposed only to spoken language. Findings suggest that while exposure to sign language does not seem to provide the bilingual child with an advantage in the rate of early linguistic development, it does appear to influence the extent to which he communicated in the manual modality and made use of its representational and combinatorial potential.

The issue of constraints on early language production has recently been a topic of great interest. Researchers have noted that although young children often display a strong desire to communicate with those around them at about the end of the first year of life, they generally do not produce their first words until after their first birthday (e.g., Bates, 1976; Bates, Benigni, Bretherton, Camaioni and Volterra, 1979). One explanation for this gap has suggested that it is imposed by the difficulties of production in the vocal modality. Because word production requires the coordination of numerous tiny muscles in the vocal tract, children who are ready to communicate may require extra time to overcome difficulties associated with oral articulation.

This proposal has led some investigators to suggest that a comparable gap between apparent "readiness" to communicate and onset of first vocabulary items may not be apparent in children exposed to a sign language from birth. In this article, we explore this issue by examining the course of early language development in a bilingual child exposed to both a sign language and a spoken language from birth. We begin by briefly reviewing what is known about the structure of sign languages and their relationship to gestures, and then turn to a discussion of the literature on early sign vs. word production.

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Sign languages and gesture

Sign languages are autonomous manual linguistic systems with lexical, morphological, and morpho-syntactic structures analogous to those found in spoken languages. There are structural similarities across sign languages, as there are across spoken languages, but there are as many different sign languages as there are national or local communities of deaf signers.

In any given sign language, a restricted number of contrastive units combine to produce the signs of the language. These units have been described as formational parameters and consist of four classes of elements: the *place of articulation*, *hand configurations* (or *handshapes*), *movement*, and *palm orientation* with which each sign is produced. Each sign language uses a specific set of locations, handshapes, movements, and orientations, combined according to language-specific rules. Systematic alterations of a given sign's formational parameters are used to signal morphological distinctions between different classes of signs (e.g., nouns vs. verbs), and grammatical categories (e.g., singular vs. plural for nouns and verbs; person, aspect, and subject–object relations in verbs). Grammatical relations are encoded by the use of marked

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locations in the signing space for specifying grammatical relations (see Pizzuto and Corazza, 1996; Pizzuto and Volterra, 2000).

A traditional misconception about sign languages is that signs are akin to spontaneous gestures that often accompany the speech of hearing people. Although signs and gestures are both produced in the manual modality, gestures differ from signs (and from language in general) in two major ways. First, in sign languages, components (i.e., the formational parameters described above, or a string of signs) are combined in a systematic, rule-governed way to form a whole (a sign, or an utterance); the meaning of the whole is thus determined by its parts. For gestures, however, the parts gain meaning because of the meaning of the whole. A gesture depicting someone running, for example, might involve wiggling fingers as the hand moves in front of the body, but the wiggling fingers themselves are not a separately meaningful component. They are interpreted as the legs and feet of a running person only because the gesture *as a whole* depicts someone running (McNeill, 1992; for additional discussion of the gesture–speech relationship, see the papers collected in McNeill, 2000).

Second, sign languages have systems of rules that govern the way in which linguistic components must be combined in order to create a well-formed structure. Structures that violate these rules are considered to be incorrect. In contrast, gestures have no such standards of well-formedness. They are often highly idiosyncratic, and the gestures of different speakers can and do present the same meanings in very different forms (McNeill, 1992).

The question of the "sign advantage"

As discussed above, difficulties with oral articulation have been proposed as an explanation for the observed gap between the onset of communicative intent and first words in children acquiring spoken language. If this explanation is correct, then a somewhat different developmental picture might be expected for children exposed to sign language. Because early sign production takes place in the manual modality, it should be unaffected by the oral articulation difficulties that presumably delay early word production. Some researchers (e.g., Bonvillian and Folven, 1987) have suggested that for this reason, signing children might be expected to produce their first signs at earlier ages than speaking children produce their first word. This proposal is based on the observation that manual control appears to develop more rapidly relative to control of the vocal tract, and that coordination of the fingers, hands, and arms is fairly well developed by the time infants produce their first words (see Iverson and Thelen, 1999, for a review).

On the basis of this observation, Bonvillian and colleagues hypothesized that such modality differences may confer an advantage on the acquisition of sign language, at least in the early stages (Bonvillian, Orlansky and Folven 1990; see also Meier and Newport, 1990). By this, they mean that early linguistic milestones may be more rapidly and readily achieved in sign language than they are in speech. To test this hypothesis, Bonvillian and colleagues followed a group of children exposed to sign language by their deaf parents through the initial stages of language development. Documenting the emergence of various early communicative milestones and comparing the age at which signing children reached these milestones with those obtained for groups of children with no sign language exposure, they reported that on average signing children experienced a consistent age advantage in linguistic development over their non-signing peers, attaining early language milestones (first word, ten-item vocabulary, first combination) several months ahead of children with no exposure to sign language (Orlansky and Bonvillian, 1985; Bonvillian and Folven, 1993).

However, Volterra and Iverson (1995) pointed out an important limitation of these studies of early sign acquisition, namely their failure to recognize the possibility that some of the signing children's early manual productions may in fact be gestures. In many studies, criteria used to identify early signs in signing children did not explicitly distinguish signs from gestures. As Bonvillian and colleagues noted, "some of the first signs reported in various studies closely resemble the gestures that all children generate, regardless of linguistic input. Therefore, even though these early gestures may lack any true linguistic component, they may be interpreted as signs" (Bonvillian et al., 1990, p. 228). Indeed, researchers who have employed criteria that distinguish between early gestures and first signs have reported that there are broad similarities between the prelinguistic gestures produced by signing and non-signing children; and when such a distinction is employed, there is no evidence of a sign advantage in early vocabulary development (Petitto and Marentette, 1991; Meier and Willerman, 1994; Abrahamsen, 2000).

In light of this evidence, Volterra and Iverson (1995) reexamined the issue of whether sign language acquisition is accelerated relative to speech development. Based on the observation that all children, whether or not they are exposed to sign language, make communicative use of the manual modality during the first two years of life, they argue against

the existence of a sign advantage. They suggest that the so-called "sign advantage" should be more properly interpreted as a "gestural advantage," in which early communication, but not linguistic development, is advantaged in the gestural modality for all children.

The present study

While the issue of whether the attainment of major early language milestones is advantaged for signing relative to speaking children has received considerable attention, no work to date has addressed the issue of whether early *gestural* development is influenced by exposure to a signed input. Here we compare the communicative gestures produced by a hearing child acquiring both a sign and a spoken language to those produced by hearing children acquiring only a spoken language (with asystematic gestural input) to shed further light on the interaction of the gestural and vocal modalities in early communicative development.

Some of the previous studies focusing on bilingualism in two language modalities have examined language development in hearing children of deaf parents, looking specifically at either sign (Bonvillian et al., 1990) or spoken language production (Mayberry, 1976; Shiff-Myers, 1988). Relatively few studies have considered sign and speech acquisition in relation to one another in these children (Prinz and Prinz, 1979, 1981; Mills and Coerts, 1990; Gregory, 1991; Petitto, Katerolos, Levy, Gauna, Tetreault, and Ferraro, 2001). Only one research group has examined the gestured, spoken, and bimodal communication production of deaf and hearing children of deaf parents (van den Bogaerde and Mills, 1995). In particular, van den Bogaerde (2000) described the signed (SLN) and spoken input (Dutch) offered by deaf mothers to three deaf and three hearing children and related this input to the language acquisition of the children between the ages of one and three years.

The aim of this study is to explore potential qualitative and quantitative differences in the use of communicative gestures as a function of modality of linguistic input. We examine possible effects of exposure to sign language on early communicative and linguistic production by analyzing longitudinal data on communication in the manual and vocal modalities in a bilingual hearing child acquiring both sign and speech. We compare these data to similar data obtained from a group of monolingual hearing children exposed only to spoken language. Specifically, we compare the manual (gestures and signs) and vocal production of the bilingual child to the manual (gestures) and vocal production of monolingual children to address two issues: (a) whether or not exposure to sign language affects production of different types of gestures; and (b) whether or not there is a sign advantage for early vocabulary acquisition and production of two-element combinations.

Method

Participants

The primary participant in this study was a hearing child of deaf parents (Marco), who was observed at monthly intervals between the ages of 11 and 29 months. Both of Marco's parents are deaf (his mother is a native signer, his father is not), and they employed Italian Sign Language (LIS; see Volterra, 1987), spoken Italian, and bimodal communication when interacting with their child. By bimodal communication, we mean that LIS signs were used simultaneously with spoken Italian. The grammatical structure of these bimodal utterances followed the rules of spoken Italian. Thus, only lexical items from LIS were combined with speech, not its syntactic structure. While Marco's father preferred to use only LIS, his mother made use of all three modes of communication, and her spoken Italian was quite clear. When we were present, Marco's parents encouraged their son to communicate in whichever modality he chose. However, we noted that Marco's mother particularly encouraged him to use spoken Italian or bimodal communication, while his father encouraged the use of LIS (for more details on linguistic input in deaf families with hearing children, see the detailed monograph by van den Bogaerde (2000)).

Marco's exposure to spoken Italian occurred primarily in two contexts: during daily interactions with his hearing grandmother and during time spent at a day nursery. Marco was enrolled in the nursery for approximately six hours a day beginning at the age of six months; adults and children at the nursery did not know sign language.[1] In light of the amount of time that Marco spent at the nursery and with his mother and grandmother, he was probably exposed to more spoken than signed input. This is consistent with van den Bogaerde's (2000) observation that the hearing children of deaf parents in her study were exposed to sign language and spoken Dutch, but also to a large

[1] Like most day nurseries in Italy, the children were divided into three groups on the basis of their ages (0–12 months, 13–24 months, and 25–36 months). Each group consisted of approximately 15 children supervised by 4 teachers. Nursery activities included free play and some structured activities, including storytelling, singing songs, manipulative activities, and gross motor activities.

degree to a mixed mode consisting of simultaneously signed and spoken lexical elements.

For purposes of comparison, data from a group of 12 monolingual hearing children observed at 16 and 20 months of age are also presented here. The monolingual children (six boys and six girls) were from upper-middle-class hearing families living in the Rome area. They were native speakers of Italian and had no exposure to sign language (for further details and description of this group of children, see Capirci, Iverson, Pizzuto and Volterra, 1996; Iverson, Capirci and Caselli, 1994).

Procedure

Videotaped observations of Marco and the monolingual children took place in their homes and lasted approximately 45 minutes. During this time, mothers were instructed to interact and play with their children as they normally would. The observations were divided equally into three 15-minute segments, so that the children were filmed in three different contexts: playing with new examples of familiar objects, playing with familiar objects, and eating a meal or snack.

Coding

All communicative and intelligible gestures and words (and for Marco, signs) were transcribed from the videotapes. Gestures, signs, and words were considered to be communicative if they were accompanied by eye contact with another person, vocalization, or other clear evidence of an effort to direct the attention of another person present in the room (Thal and Tobias, 1992).

Because gestures and signs are produced in the same modality, and in light of the observation that early signs often resemble the gestures produced by hearing children (Bonvillian et al., 1990), the establishment of coding criteria that distinguished between the two presented us with a unique problem. Moreover, as noted above, such a distinction has not been made in previous work. The criteria employed here to distinguish gestures from signs are empirical; they entailed comparing Marco's manual productions to those of monolingual children. This procedure may have underestimated Marco's sign vocabulary to some extent, but it seemed to us to be the most appropriate. Thus, communicative manual signals were defined as signs only when: (a) they resembled adult LIS forms; *and* (b) their form differed from that produced by monolingual children. An exception was made in the case of some pointing gestures, which are also pronoun forms in LIS. For instance, when Marco pointed to himself and then produced the sign for **bravo**, the point was glossed as **I** in this case, rather than as a pointing gesture to self.

All manual signals were subsequently reviewed by a native signer, who judged whether a given signal should be classified as a sign or a gesture. The assistance of the native signers was particularly important in identifying baby sign forms that were simplified or slightly different from the adult form (e.g., the sign **bravo** produced with all five fingers extended, rather than just the thumb, index, and middle fingers). Such forms were counted as signs, just as simplified or incorrect pronunciations of words often are in studies of spoken language acquisition.

All of Marco's manual productions that failed to meet the two criteria outlined above were classified as gestures. Thus, for example, although the LIS sign for **good** is executed by rotating the index finger on the cheek, instances of this form were classified as gestures for Marco because the gesture GOOD is produced in the same way by monolingual Italian children.[2]

All gestures were further classified into one of two categories. *Deictic gestures* indicate only the occurrence of an event or the existence of an object. Because the form of the gesture bears no direct resemblance to its referent, deictic gestures express communicative intent by presenting objects for another's attention. Three types of deictic gestures were coded: SHOWING, POINTING, AND REQUESTING. A gesture was coded as SHOWING when an object was held up in the center of the gesture space and oriented toward the interactive partner. Gestures were classified as POINTING when a finger (usually the index) was extended toward a specific person, object, location, or event. Finally, gestures in the REQUESTING category consisted of instances in which the child extended the hand and arm toward a referent, in some instances repeatedly opening and closing the fingers.

The second category of gestures, *representational gestures*, refer to objects, persons, locations, or events through hand, body, or facial movements. Such gestures differ from deictic gestures in that they represent attributes or actions of specific referents and their meaning does not change appreciably across different contexts (e.g., opening and closing the mouth for FISH; holding hands formed as circles in front of eyes for BINOCULARS; extending and retracting the index finger for SNAIL). Also included in this category were conventional gestures whose

[2] Throughout this article, gestures are denoted in SMALL CAPITALS and signs are indicated in **boldface**.

form and meaning are culturally defined (e.g., shaking the head NO; opening and closing the hand repeatedly with palm turned inward for CIAO, raising the palms upward for ALL GONE).

Results

We begin by presenting data on Marco's use of gestures, words, and signs (in terms of vocabulary size and overall production) and compare them to data obtained from monolingual children. Next, we describe Marco's production of two-element combinations in terms of the types of elements they contain (i.e., gestures, signs, and/or words) and compare them to those produced by monolingual children. Finally, we examine the informational content of Marco's early two-element combinations and compare them to those of monolingual children.

Production of gestures, words, and signs

Figure 1a presents the number of gesture, word, and sign types (i.e., number of different items) produced by Marco from 11 to 29 months. At 11 and 13 months, Marco's repertoire consisted primarily of gestures, with words and signs appearing in relatively small numbers. By 16 months, Marco's repertoire consisted of approximately the same number of gestures and words, while the number of signs remained unchanged. Between 16 and 19 months, there was a substantial increase in the size of Marco's word and sign repertoires, but not in the number of gestures. From 19 to 22 months, Marco's word vocabulary exhibited the typical spurt, nearly tripling in size, while the number of gestures and signs remained constant. Finally, between 25 and 29 months, there was a rapid increase in the size of the sign vocabulary. By 29 months, Marco's sign and word vocabularies were roughly comparable in size (82 signs vs. 93 words).

We next explored the extent to which individual items within Marco's representational gesture, representational word, and sign repertoires overlapped in meaning. For this analysis, we counted the number of representational words that were equivalent in meaning to representational gestures at each observation. We then calculated the percentage of overlapping items by dividing this number by the total number of representational gesture and word types produced at this age. The same procedure was followed to obtain the percentage of representational words that overlapped in meaning with signs.

There were different developmental patterns of semantic overlap for words and gestures than for words and signs. With regard to words and gestures,

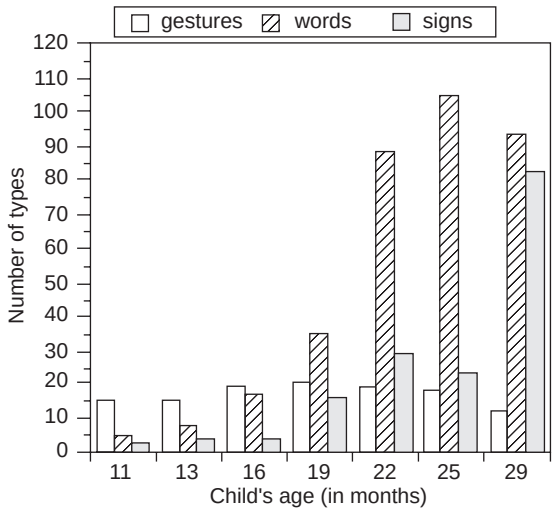

Figure 1a. Number of gesture, word, and sign types produced by Marco.

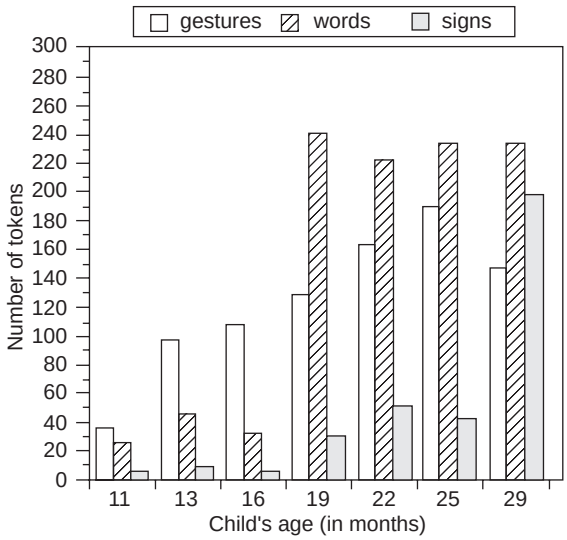

Figure 1b. Number of gesture, word, and sign tokens produced by Marco.

approximately 30% of all word and gesture types referred to the same referent prior to the onset of the word vocabulary spurt, and the percentage of semantically overlapping words and gestures remained at around 20% through the remainder of the period of observation. However, comparison of the word and sign vocabularies over development revealed a different pattern. At 13 and 16 months, relatively few signs and words had equivalent meanings (0% at 13 months and 12% at 16 months respectively). Initially, Marco tended to have either a word or a sign for a given referent, but not both. However, by 19 months, when signs began to appear in appreciable numbers, the trend was reversed; at this age, 62% of Marco's words and signs were semantically equivalent. This

suggests that Marco's word and sign vocabularies were developing in parallel, as separate lexicons from two distinct languages. A similar trend was not observed for gestures and words, however, presumably because the gestural repertoire will not attain the level of structure and organization observed in the word and sign lexicons.

The number of gesture, word, and sign tokens (i.e., total number of items produced, including repetitions) is presented in Figure 1b. As is evident, there was a developmental shift in Marco's preferred mode of communication. Initially, Marco used gestures to communicate more frequently than either words or signs. This preference for gestural communication continued until 19 months, when words began to outnumber gestures. Between 16 and 25 months, sign tokens increased gradually, and there was a jump in production between 25 and 29 months, the period in which sign vocabulary size also increased sharply. By 29 months, Marco communicated almost as frequently with signs as with words, and gesture production had begun to decline.

Comparison with monolingual children

We next compared Marco's production to that of the group of 12 monolingual children observed at 16 and 20 months, focusing first on production of types and then on production of tokens. If it is the case that exposure to a signed input affects the extent to which the gestural modality is employed in communication, then we might expect Marco to produce more gestures (in terms of both types and tokens) relative to his monolingual peers.

Figure 2a presents the mean number of gesture and word types produced by the monolingual children and Marco at 16 and 20 months. As is apparent in the figure, Marco produced many more gesture types than did monolingual children at both 16 and 20 months. To determine whether the number of gesture types produced by Marco fell within the range for monolingual children, we converted the total number of gesture types for Marco to a standardized z-score for the distribution of gesture types obtained for monolinguals. We found that at both ages, the number of gesture types produced by Marco fell more than two standard deviations above the means for the monolingual group ($M_{16} = 9.58$, $z = 10.84$, $p < .001$; $M_{20} = 10.0$, $z = 7.63$, $p < .001$).

In light of the fact that Marco produced many more gesture types than did monolingual children at both 16 and 20 months, and because there were by definition only three deictic gesture types (SHOWING, POINTING, AND REQUESTING) that could have contributed to the total numbers obtained both for Marco and the monolingual children, we repeated this analysis on the number of representational gesture types produced by Marco and the comparison group. Once again, Marco's production of representational gesture types fell more than two standard deviations above the mean obtained for monolingual children at both ages ($M_{16} = 6.58$, $z = 8.94$, $p < .001$; $M_{20} = 7.0$, $z = 6.11$, $p < .001$).[3]

With respect to the production of word types, the data in Figure 2a indicate that at 16 months, the number of word types produced by Marco fell within the 95% confidence interval of the distribution for the monolingual children ($M = 24$, $z = -.92$, n.s.). At 20 months, Marco's word type production fell more than two standard deviations below the mean for monolingual children ($M = 64$, $z = -2.54$, $p < .01$). However, in light of the high degree of variability in number of word types observed among monolingual children at 20 months (SD = 11.4), we repeated the analysis using only data from the six monolingual children who fell in the lower half of the distribution (range 5–67 words). Results revealed that Marco's word type production at 20 months fell within the 95% confidence interval of the distribution for this subgroup of monolingual children.

The data presented in Figure 2a indicate more generally that when both modalities are considered together, Marco's total repertoire size (i.e., gestures and words) fell within the range for the monolingual children ($\text{Marco}_{16} = 36$; $M_{16} = 33.25$; $\text{Marco}_{20} = 55$; $M_{20} = 74.08$). In other words, his productive repertoire was neither advantaged nor limited relative to children not exposed to sign language input.

Turning now to the production of tokens, as is evident in Figure 2b, Marco used almost twice as many gestures as did his monolingual counterparts at both 16 and 20 months (108 and 128 gestures respectively), and his gesture token production fell more than two standard deviations above the means for monolingual children ($M_{16} = 50$, $z = 7.15$, $p < .0005$; $M_{20} = 74$, $z = 4.6$, $p < .0005$). With respect to word production, however, Marco's totals (32 words at 16 months and 240 words at 20 months) fell within the 95% confidence intervals for the monolingual distributions at both ages ($M_{16} = 67$, $z = -1.54$, n.s.; $M_{20} = 197$, $z = 1.08$, n.s.).

Interestingly, at 16 months, Marco exhibited a strong preference for gestural compared to spoken communication, a pattern that was also observed among 5 of the 12 monolingual children. By 20

[3] This difference was not due to our decision to count as representational gestures any of Marco's manual productions that were sign-like but did not meet our criteria for sign status. At 16 months, none of Marco's representational gestures were possible signs; at 20 months, only 2 of 15 representational gestures were sign-like.

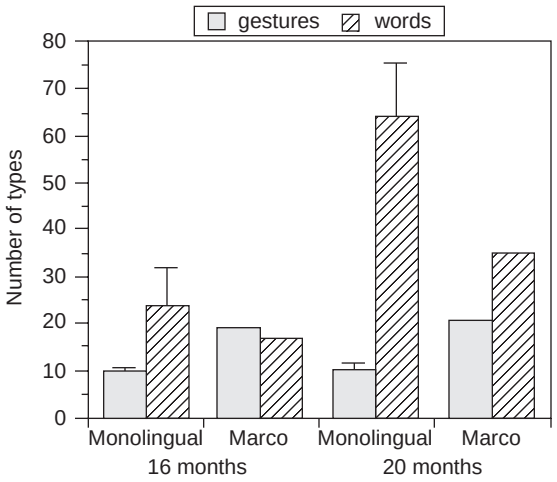

Figure 2a. Number of gesture and word types produced by 12 monolingual children and Marco at 16 and 20 months.

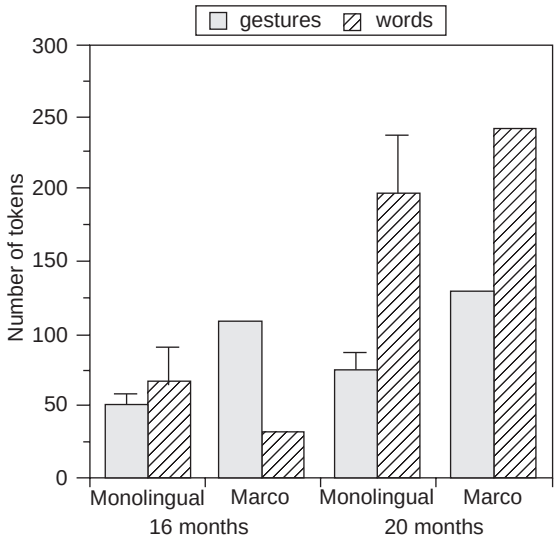

Figure 2b. Number of gesture and word tokens produced by 12 monolingual children and Marco at 16 and 20 months.

months, however, this preference had shifted, and Marco now produced words more frequently than gestures, as did a majority of the monolingual children. This suggests that although Marco's exposure to a sign language input may have influenced the extent to which he used gestures to communicate, the overall developmental pattern of gesture and word use was very similar to that of monolingual children.

In addition to affecting the extent to which Marco used gestures to communicate, experience with a signed input also appeared to have qualitative effects on gesture production. When we compared the proportions of deictic and representational gestures produced by Marco to those obtained for the monolingual children, an interesting difference was observed. At both ages, monolingual children produced deictic gestures much more frequently than representational gestures. On average, at 16 months 68% of all gestures produced were deictic and 32% representational; at 20 months, 80% were deictic and 20% representational. However, Marco showed an opposite trend and used more representational than deictic gestures at both ages (48% deictic vs. 52% representational at 16 months and 38% deictic vs. 62% representational at 20 months).

In sum, Marco's earliest communications consisted primarily of gestures, a finding consistent with other reports in the literature indicating that children's earliest communicative signals are produced in the gestural modality (see Iverson and Thal, 1998, for a review). Initially, new words and signs were added to the lexicon at a relatively slow rate, but this was followed by a period of rapid growth that occurred first in the word and then in the sign vocabulary. Marco's early preference for gestural communication was eventually replaced by a preference for verbal and signed communication. By the end of the observation period, Marco's word and sign vocabularies were approximately the same size, and he used sign and speech to communicate with roughly equal frequency. And with the exception of an increased use of communicative gestures (particularly representational gestures), the developmental patterns of gesture and word production displayed by Marco were quite comparable to those of monolingual children in terms of both types and tokens.

Despite the fact that a spurt occurred in Marco's sign vocabulary, a similar pattern of growth was not observed in his gestural repertoire. This observation further supports the notion that signs differ from gesture because they are part of a structured linguistic system, while gestures are not.

Production of two-element combinations

In this section, we describe the production of early two-element combinations by Marco and the monolingual children, focusing first on combination structure and then on informational content.

Combination structure

Since bilingual signers/speakers can produce linguistic elements in two modalities, they have combination structures available to them that are not available to monolingual children (i.e., gesture + sign, sign + sign, word + sign). In addition, two of these combination structures (gesture + sign and sign + sign) consist of elements produced in the manual modality.

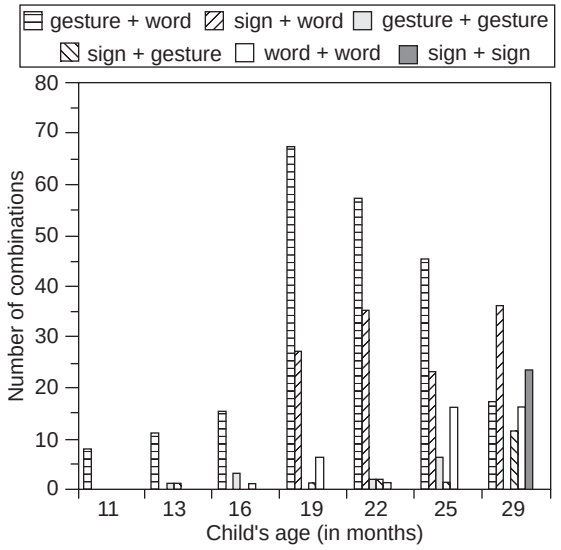

Figure 3. Number of two-element combinations produced by Marco.

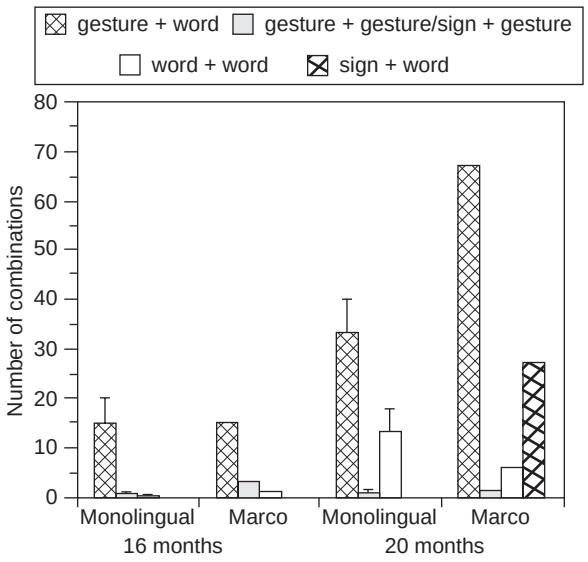

Figure 4. Number of two-element combinations produced by 12 monolingual children and Marco at 16 and 20 months.

We categorized all of Marco's two-element combinations according to the types of elements they contained (i.e., gesture + word, sign + word, gesture + sign, sign + sign, word + word, gesture + gesture); all combinations containing gestures were further categorized on the basis of the type of gesture they contained (deictic or representational). These data are presented in Figure 3. For purposes of clarity, we present the data on gesture + word combinations collapsed across the two categories and provide further details in the text below.

As is evident, gesture + word combinations were the first to appear at the age of 11 months; Marco produced two combinations of a deictic gesture and a representational word (DG + RW). At 13 months, representational word + representational gesture combinations (RG + RW) were first observed; Marco produced 3 DG + RW and 8 RG + RW combinations. Deictic gesture + deictic word (DG + DW) combinations appeared at 16 months; at this age Marco produced 4 DG + RW, 3 DG + DW and 8 RG + RW combinations. By 19 months, production of gesture + word combinations increased sharply (in all, 27 DG + RW, 3 DG + DW, and 37 RG + RW combinations were noted) and then began a progressive decline as sign + word combinations began to appear in substantial number.

With regard to other combination structures, gesture + gesture and sign + gesture combinations first appeared at 13 months and remained relatively infrequent through the remainder of the observation period. Word + word combinations first emerged at 16 months but remained few in number until 25 months. Sign + sign combinations first emerged at 29 months, the age at which Marco also attained the 50–sign milestone (see Figure 1a).

We next compared Marco's pattern of production of combination structures at 16 and 20 months with means obtained from the monolingual children. These data are presented in Figure 4. At 16 months, Marco's relative distribution of combinations across structure types was generally similar to that of monolingual children. Indeed, the total number of gesture + word combinations produced by Marco was within the 95% confidence interval for the monolingual distribution ($M = 15.16$, $z = -0.03$, n.s.).[4] Both Marco and the monolingual children produced relatively few gesture + gesture and word + word combinations at this age. By 20 months, however, Marco's overall production of gesture + word combinations was more than two standard deviations above the group mean for monolingual children ($M = 33.41$, $z = 4.95$, $p < .0005$). In fact, Marco produced more gesture + word combinations than any of the monolingual children. With respect to word + word combinations, however, Marco's production was within the 95% confidence interval for the monolingual distribution ($M = 13.25$, $z = -1.57$, n.s.). Gesture + gesture combinations remained infrequent for both Marco and the monolingual children. Interestingly, combinations of two representational gestures were produced occasionally by Marco but were never observed among the monolingual children.

[4] No statistical analyses were carried out on data from the remaining categories due to the small numbers of combinations they included.

Informational content

Thus far, we have indicated that, for Marco, crossmodal gesture + word combinations were the first two-element combinations to emerge, an observation similar to that reported for monolingual children (e.g., Capirci et al., 1996; Butcher and Goldin-Meadow, 2000). These crossmodal combinations can be used to convey two different pieces of information in a single, integrated utterance, thereby eliminating the problem of coordinating articulatory movements necessary for the production of two words (Capirci et al., 1996). Crossmodal combinations, in other words, appear to reflect a compromise between "readiness" to produce word combinations and constraints on the ability to produce two words in succession.

The fact that Marco produced such a large number of crossmodal combinations (gesture + word and sign + word) relative to his monolingual peers raises an additional question. Did the production of such combinations provide Marco with a communicative advantage over his peers? Specifically, did Marco make use of sign + word (in addition to gesture + word) combinations to convey two different pieces of information, something that his non-signing peers can only do using gesture + word combinations?

To address this question, we further classified combinations according to their informational content. In previous work (Capirci et al., 1996), we grouped children's early combinations into three categories: equivalent, complementary, and supplementary. *Equivalent* combinations included only gesture + word and sign + word productions of two representational units that typically referred to the same referent and conveyed the same meaning (e.g., YES + "yes"; BYE-BYE + "bye-bye"; **carnival** + "carnival").[5] *Complementary* combinations typically referred to a single referent, and they always included one deictic element (gestural or vocal) which provided non-redundant information, singling out or disambiguating the referent indicated by the accompanying representational element or by another, cooccurring deictic element (e.g., SHOW toy + "this"; POINT to camel + **camel**). *Supplementary* combinations differed from the other two types in that they referred either to the same or to two distinct referents, but in all cases each of the combined elements added information to the other one (e.g., "later" + "beach"; **cheese** + **lunch**).

Figure 5 presents the total number of equivalent, complementary, and supplementary combinations (summed across combination structure categories) produced by Marco at 16 and 20 months along with the group means obtained for the monolingual children. At 16 months of age, Marco and the monolingual children displayed similar overall patterns of equivalent, complementary, and supplementary combination production. But while Marco's production of complementary and supplementary combinations fell within the 95% confidence intervals for the monolingual distributions ($M_{\text{complementary}} = 6.83$, $z = 0.08$, n.s.; $M_{\text{supplementary}} = 5.66$, $z = 0.03$, n.s.), his production of equivalent combinations fell more than two standard deviations above the mean for monolingual children ($M = 3.75$, $z = 3.79$, $p < .01$).

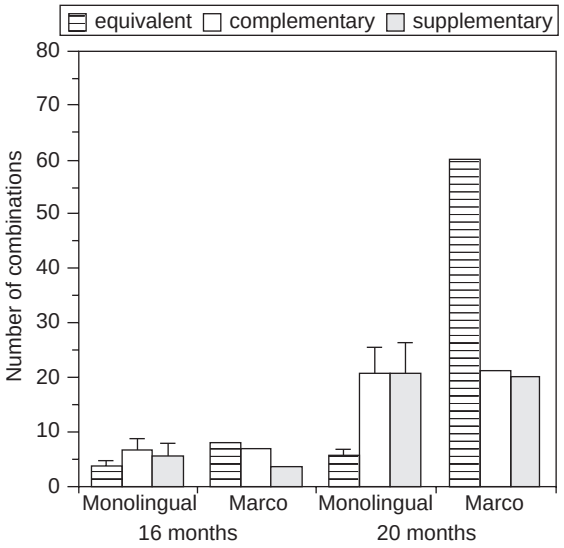

Figure 5. Number of equivalent, complementary, and supplementary combinations (summed across combination structures) produced by 12 monolingual children and Marco at 16 and 20 months.

At 20 months, the pattern of complementary and supplementary combination production was once again comparable for Marco and the monolingual children, and the total numbers of complementary and supplementary combinations produced by Marco fell within the 95% confidence intervals for the monolingual distributions ($M_{\text{comp}} = 20.91$, $z = 0.02$, n.s.; $M_{\text{supp}} = 20.83$, $z = -0.15$, n.s.). The difference in production of equivalent combinations was much sharper at this age, with Marco producing more than ten times as many equivalent combinations as his monolingual counterparts ($M = 5.5$, $z = 12.70$, $p < .001$).

To explore the nature of this difference, we reclassified all of the combinations contained in Marco's equivalent category according to their structure (i.e., gesture + word, sign + word, etc.).

[5] In these examples, SMALL CAPITALS and quotation marks are used as previously, denoting gestures and words respectively, and signs are indicated in **boldface**.

This examination revealed that almost all of Marco's equivalent combinations (N = 60) consisted of sign + word (44%, N = 27) or representational gesture + representational word (54%, N = 32). Moreover, all of the sign + word and approximately half of the gesture + word combinations (all of which were RG + RW) produced by Marco at this age conveyed equivalent information (e.g., **work** + "work"; **pinocchio** + "pinocchio"; NO + "no"). Thus, while the availability of sign + word combinations may have provided Marco with additional means for communicating two different but related pieces of information, the availability of this structure clearly did not enhance his production of supplementary combinations relative to that of his monolingual counterparts.

Why might Marco make such great use of equivalent sign + word combinations? We suspect that it is in part a reflection of the nature of the input to which he was exposed (see also van den Bogaerde and Mills, 1995). Although Marco's mother used both LIS and spoken Italian when communicating with her child, she often used signs and words simultaneously, a tendency that increased as Marco grew older. Thus, Marco's extensive use of informationally redundant sign + word combinations may be the product of frequent experience with bimodal communication in everyday interactions. A similar conclusion was reached by Petitto et al. (2001) and van den Bogaerde (2000).

Discussion

Previous research that has focused primarily on the question of whether children exposed to sign language exhibit precocious linguistic abilities has left an important issue unaddressed: whether early exposure to sign language affects children's production of *gestures*, and, more generally, their communicative use of the manual modality. In this study, we addressed two major questions: (a) does exposure to sign language affect production of different types of gestures? and (b) is there a sign advantage with respect to speech for early vocabulary acquisition and production of two-element combinations?

Exposure to sign language and gesture development

With regard to the first question, our data indicate that Marco did make relatively greater communicative use of the manual modality, both in terms of the use of representational gestures and the production of equivalent sign/gesture + word combinations. With respect to representational gestures, Marco produced proportionately more representational than deictic gestures relative to monolingual children at both comparison ages. This suggests that exposure to sign language may attune bilingual children to the ways in which representational information can be captured by the manual modality.

Interestingly, while Marco occasionally combined two representational gestures, monolingual children never did so, despite the fact that they produced a considerable number of single-gesture utterances and combined gestures with words at both 16 and 20 months. That children exposed exclusively to speech make use of gesture in this way suggests that the general ability to produce single representational signals and the capacity to combine communicative elements are not directly determined by exposure to a modality-specific linguistic input (Caselli and Volterra, 1990; Volterra and Iverson, 1995). However, the ability to combine two representational gestural elements does not appear to develop spontaneously in children who are not exposed to sign language input, and not even in children who are immersed in a rich gestural environment, as are Italian children. For the bilingual child who is simultaneously acquiring sign and speech, combinations of representational elements in the manual modality are regular features of the linguistic environment. The emergence of such combinations in the child's spontaneous production is reflective of the fact that for this child, the manual modality has assumed properties that are characteristic of language.

The sign advantage revisited

With respect to the second question, the issue of whether there is a sign advantage in early acquisition, our findings indicate that for this child, sign language acquisition did not precede spoken language acquisition. Indeed, for Marco, signs appeared relatively late and were acquired at a slower rate than words. In addition, the size of Marco's total repertoire fell well within the ranges obtained for monolingual children at both comparison points. In other words, he was neither advantaged nor disadvantaged relative to his monolingual peers.

These results provide additional insight into constraints on the production of two-word combinations. One possibility is that the constraints stem from difficulty coordinating production of two spoken elements; they should thus be specific to the vocal modality. If this is the case, then combinations produced entirely within the manual modality (i.e., gesture + gesture, gesture + sign, sign + sign) should emerge before two-word combinations in the bilingual child. Alternatively, if the difficulty with two-word combinations lies in the general problem of

within-modality coordination of two symbolic elements, then crossmodal gesture + word and sign + word combinations should precede the emergence of other combination types.

Our data indicate that, like the monolingual children, Marco produced gesture + word combinations before word + word combinations. Gesture + word combinations emerged before sign + word combinations in Marco's production; and gesture + word combinations also preceded the appearance of two-element combinations within the manual modality (i.e., gesture + gesture and sign + sign). The fact that these latter combinations did not appear before gesture + word combinations and were produced in relatively small number provides some support for the view that constraints on production of two-word combinations cannot be attributed solely to the presumably greater difficulty of production in the vocal relative to the manual mode. Instead, the appearance of crossmodal combinations (gesture + word and sign + word) prior to combinations of two properly linguistic elements (i.e., word + word and sign + sign) suggests that the difficulty lies in the combination of two such elements in the same modality.

This interpretation is further supported by the finding that within the corpus of gesture + word combinations produced by Marco, all those consisting of two representational elements (RG + RW) were informationally equivalent, while only those that consisted of one deictic element (usually a deictic gesture) and one representational element were complementary or supplementary. Thus, like monolingual children who are not yet able to combine two representational elements in a supplementary fashion, the bilingual child appears to pass through a transitional phase in which he "experiments" with combining elements in a supplementary fashion by making use of structures that consist of a deictic element (usually a deictic gesture) with a representational element (usually a representational word).

Taken together, these findings suggest that the problem of combining two linguistic symbols in a supplementary fashion must be solved by all young language learners, regardless of the modality of the input to which they are exposed. The difficulty that children must overcome as they begin to produce two-element combinations is a general, cognitive one; specifically it is related to constraints on combining two linguistic symbols in a supplementary fashion, regardless of the modality in which they are produced. On this view, producing supplementary, crossmodal combinations of two linguistic symbols (i.e., supplementary sign + word combinations) carries the same degree of difficulty and cognitive complexity as production of supplementary combinations of elements within the same modality (i.e., sign + sign, word + word). These data further suggest that children are able to distinguish communicative input (i.e., gestures) from linguistic input (i.e., words and signs), and that they combine only those symbols that are presented to them in the context of organized linguistic structures.

Exposure to a manual language does not seem to offer an alternative route into the production of supplementary combinations of two symbolic elements. Despite the fact that Marco had an additional combination type (sign + word) available to him, he did not make use of sign + word combinations to communicate two related pieces of information. Thus, he did not appear to be "advantaged" in production of supplementary combinations relative to his monolingual peers.

Conclusion

Although our findings on the use of gestures, signs, and words are taken from a case study and must therefore be interpreted with caution, we believe that they shed important light on the nature of the cognitive processes that underlie language acquisition. This is one of a very small number of studies that has charted the development of gestural, spoken, and signed communication in the same child over a relatively extended time period. The data gathered in the course of this study have given us the unique opportunity to examine two relatively unexplored issues.

The first issue has to do with the fact that signs and words appear to follow similar developmental trajectories, a finding consistent with prior studies of bilingual sign/speech acquisition (Gregory, 1991; van den Bogaerde and Mills, 1995). In line with these previous reports, our data indicate that signs and words share two important features. Growth in the two vocabularies was non-linear, with a sudden spurt occurring in each after a period of relatively slow expansion. Moreover, two-word and two-sign combinations appeared once a vocabulary of about 50 words and 50 signs respectively had been acquired.

The second issue has to do with the finding that the developmental trajectory followed by gestures is different not only from that followed by words (Caselli, 1990; Iverson et al., 1994; Capirci et al., 1996), but also from that observed for signs. Thus, there was little, if any, growth over time in the size of the gestural repertoire. And although Marco occasionally combined two representational gestures (unlike the monolingual children), two-gesture combinations never became productive in the way

that two-sign combinations did. This is striking in light of the fact that gestures and signs are produced in the same modality, and it suggests that what distinguishes gestures from words is not simply modality of production. Words and signs belong to structured linguistic systems, while gestures do not, and this is what differentiates the development of gestures from that of words and signs.

In conclusion, our findings suggest that gesture is a robust feature of early communicative development, even in a child exposed to a manual language from birth. This role appears to be especially important during moments of transition, such as the transition from one- to two-element utterances. Further work is needed to detail the initial stages of communicative development in deaf children exposed to sign language. Such studies will enable us to refine the criteria used to distinguish gestures and signs and contribute to our understanding of the role played by gesture in the acquisition of a manual language.

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